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WEEKLY SUCCESSION OF GULF STREAM TEMPERATURES IN THE STRAITS OF FLORIDA

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[Clark University, Worcester, Mass., April 30, 1930

Sea water thermograms of twice daily crossings of the Straits of Florida were presented in the previous paper. (1). This discussion deals with the data tabulated from these thermograms and reduced to weekly means.

REDUCTION TO TABULAR FORM

A detailed study of the temperatures recorded by the thermograph requires the tabulation of the thermograms. Each trip of the ship provides a profile from which any number of temperatures may be read. The sharp contrasts in temperature that occasionally develop within short distances leads the investigator to read the thermograms for as small time intervals as practicable. The limits of detailed study would seem to be reached by mean and extreme values for each twelfth of the width of the Straits, and for the passage of the ship through the shallow waters at each end of the trip. Furthermore, the mean sea temperatures recorded at Key West or Habana provide a rough indication of the level to which the weather then prevailing was tending to raise or lower the Gulf Stream temperatures. Thus, if the shallow harbor water were much warmer than the Gulf Stream, we conclude that local weather was having a decided warming effect on the surface of the Gulf Stream.

Method of tabulation.—The tabulation of these values has been beset with many difficulties. For reading without the aid of a special time scale, a trip across the Straits is divided into twelfths, by taking the time from sea buoy to sea buoy, or from sea buoy to hauled log [1] plus 5 or 10 minutes, and dividing by 12. The number of minutes found in each twelfth is usually from 35 to 40 for the southbound trip and 30 to 33 for the northbound. The proper number of minutes is added to the outgoing sea-buoy time, giving the clock time during which the first twelfth was traversed. The number added again shows the limits of the second twelfth, etc. The thermogram must be examined with care to note whether the clock error for the trip exceeded a negligible 5 or 10 minutes. In spite of the engineer's careful attention, the smallness of the time scale, about 0.1 inch per hour, makes an error of less than 20 minutes difficult to avoid. The characteristic features of temperature change at the beginning and end of each trip make it readily possible, however, to gauge the amount of clock error. Once found, the times for each twelfth are corrected to the apparent time on the thermogram. Then the temperatures can be integrated for each twelfth to the nearest tenth or two-tenths of a degree Fahrenheit and recorded on a convenient form.

Much labor may be saved by ruling a thin sheet of celluloid with 12 equally spaced diverging curved lines crossed nearly perpendicularly by a number of equally spaced straight lines. The curved lines are drawn so that near one end of the scale the space between the two outermost lines is equal to the thermogram time-scale value for the shortest trip, while near the other end of the scale, the diverging lines are so adjusted that the total width between the outermost lines equals the longest time required to cross. The cross lines are marked numerically to indicate how long a trip each one represents. The cross line appropriate to the duration of the trip to be tabulated is placed over the record for the first twelfth in a position parallel to the horizontal temperature-scale lines on the thermogram. By slight shifting up or down this cross line can be made to strike an average for each twelfth in succession, by laying it so that the area outlined by the trace is as much above as below the line. But it is usually easier to hold the scale stationary and to estimate the means for each twelfth. The highest and lowest temperatures of each twelfth, or of each quarter with the hour and minute each occurs, and also the temperatures from sea buoys to harbors complete the tabulation. The tabulation is checked by another person by a second reading.

The primary tabulation is summarized onto another sheet, from which times are omitted, and here the twelfths are averaged by quarters and by halves from which the end twelfths have been omitted. The daily values are averaged into weekly. The *Henry M. Flagler* thermograms from July, 1928, to May, 1929, were tabulated by Hazel V. Miller, mostly at the Washington office, United States Weather Bureau, on grants from the American Meteorological Society and Clark University. Those from May, 1929, to June, 1930, were tabulated at Clark University, by Edwin N. Johnson and Frances Richey. All the tabulations were checked by C. F. Brooks and Edith M. Fitton. The receipt of sea-buoy and hauled log times in October, 1929, from Capt. W. I. Jackson and Chief Engineer C. H. Stanton, S. S. *Henry M. Flagler*, which before December, 1928, and May, 1929, respectively, were not entered on the thermograms, made a more exact tabulation of parts of the first few months of record possible. So those strips for which the exact times showed more than 5 or 10 minutes' departure from the original readings were tabulated a second time, mostly

[1] The time when the patent log is hauled in at the end of a trip, usually a mile or two (5 or 10 minutes) off the harbor entrance. Sometimes the ship waits outside for its sister ship to come out of the single berth. Thus, the hauled log time may be half an hour to an hour or more before the ship passes the sea buoy to enter the harbor.

by C. F. Brooks, the first tabulations being used as a partial check on the new. Where the hauled log times were no more than 10 minutes prior to the Habana sea-buoy times, the hours and minutes from sea buoy to sea buoy were used as the whole crossing, and divided into twelfths.

Owing to the sharp changes in temperature found on some of the thermograms, particular care had to be exercised to read the time to within 10 minutes and to strive for 5. An error of 10 minutes might make a difference of 1° in the mean for one twelfth.

The tabulations by days are not presented in this study for the reason that they would serve only for a detailed investigation of temperature changes from day to day and diurnal ranges and their relation to the weather at the time and the immediate past.[2] Here are offered in Table 1, the weekly values, tabulated, reduced, and checked, by C. F. Brooks, and Edith M. Fitton and in part by Hazel V. Miller, by which, in spite of the gaps, a fair idea of the annual course in temperature may be obtained. In Table 2 the weekly means of the daily temperatures by quarters and weekly means by halves

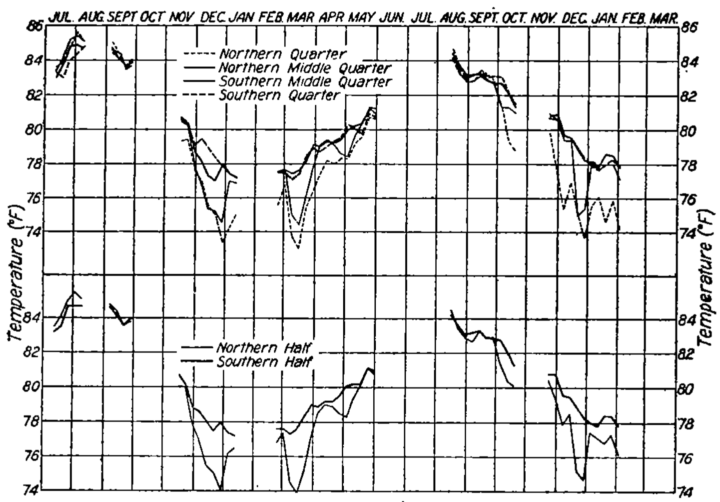

FIGURE 1.—Gulf Stream temperatures (south bound) by quarters and halves

of the Straits are presented. The values for the north and south halves in this table were computed from the weekly means inner ten twelfths of the Straits proper, omitting the marginal twelfths on either side, since these sections of the Straits, being shallower water and out of the main current, are more subjected to local temperatures and shallow water upwelling from wind action.

GRAPHIC REPRESENTATIONS OF TABULATIONS

These tables are presented here to provide investigators with accurate Gulf Stream data in small enough time and space units for any combinations they may desire. The graphic representations of the tabulations which are presented in Figures 1 to 3 may serve to make more prominent the outstanding features of the weekly course of temperature for the different divisions of the Gulf Stream in the Straits.

Figure 1 illustrates the weekly succession of temperatures for each of the four quarters of the Gulf Stream in the open Straits from the Key West sea buoy to the Habana sea buoy from July, 1928, to February, 1930. The southbound (nighttime) trips were chosen because the nighttime temperatures represent those of a convectionally mixed thicker layer of water than the top, heated, daytime layer. Nevertheless, there is naturally a very close parallelism between the temperatures of the southbound and northbound trips since the car ferry stays in Habana Harbor only about two hours before returning, and not much change in sea water temperature could generally be effected in that length of time. Moreover, the graphs show weekly averages, so any irregular variations that might occur between the two trips become more or less smoothed out, and only the small diurnal difference remains. In the 56 cases for which weekly averages of sea temperatures were obtained, July, 1928, to February, 1930, the nighttime temperatures average 0.31° F. below the daytime for the north half of the Straits and 0.24 °F. below for the south half. For the north half there were 42 cases of lower nighttime temperature (av. −0.45° F.), 8 cases of higher nighttime temperature (av. +0.22° F.), and 6 cases of the same temperature. For the south half there were 44 cases of lower temperature (av. −0.32° F.), 4 cases of higher temperature (av. +0.12° F), and 8 cases of the same temperature.

The contrast between the north and south portions of the Straits is plainly shown in this graph. While for the width of the Straits as a whole, the annual range of sea surface temperature is 9° F., from 76° to 85°, the north quarter has a greater range than the south, being 2° or 3° colder in winter and 1° or less warmer in summer, a range of 11.7°, from 73.4° to 85.1°, compared with 7°, from 77.5° to 84.5°, in the south. During August and September, all four quarters are nearly alike in temperature, as is shown by the close crowding of the lines in the graph in these months, the temperatures for all the quarters occurring within the limits of less than one degree then, while during the winter months the limits are generally 4 or 5 degrees apart. The weekly course of temperature by halves, bottom of Fig. 1, summarizes this contrast between north and south. The north half ranges 10.7°, from 74.3° to 85.0°, and the south half 7°, from 77.5° to 84.5°.

The chief reason for the greater temperature range in the north portion of the Straits probably lies in the fact that the water comes mainly from the Gulf of Mexico, while the Caribbean supplies the south portion. The north portion thus receives a water supply from a source which (*a*) is more subject to continental temperature changes, (*b*) comes from a higher latitude, (*c*) is shallower in part, and (*d*) provides a current generally less strong, than in the south portion.

The lowest temperatures are reached in the northernmost quarter; the major minimum comes in March, with a secondary (cool wave) minimum in December. The northernmost quarter also reaches the highest temperature, its maximum coming in late July or early August. Because the record is broken in these two months in both years, it is difficult to state an exact maximum, as it might have been reached during the time when the car ferry was making no trips.

Figure 2 permits comparison of the Gulf Stream temperatures at the same dates in the two successive years. The graph runs from July to June, and, so far, is double only from July to April. As more thermograms are received year after year, the graph can be added to and will then show more clearly whether there is parallelism or not from year to year. The figures from which the graph was made (see table 2) are for the north and south halves of each trip, from which the more locally influenced marginal twelfths have been omitted. It seems fairly

[2] The daily values are being filed, however, in the Library, and the original records with the Marine Division, of the United States Weather Bureau, Washington.

certain that marked parallelism from year to year will continue to be found, since those portions of the graph which are now double show a very close parallelsim between 1928–29 and 1929–30 for both north and south halves of the stream. Even the exceptional early winter drop in temperature in the north half occurs at the same time in both of the years of record—the end of December—perhaps only by coincidence, however.

The relation of local air temperatures to the Gulf Stream temperatures was studied by means of diagrams. Averages of Key Wext maximum, minimum, and mean air temperatures were calculated for the same weeks for which sea water temperatures were obtained and were plotted on graphs together with the following sea tempera-

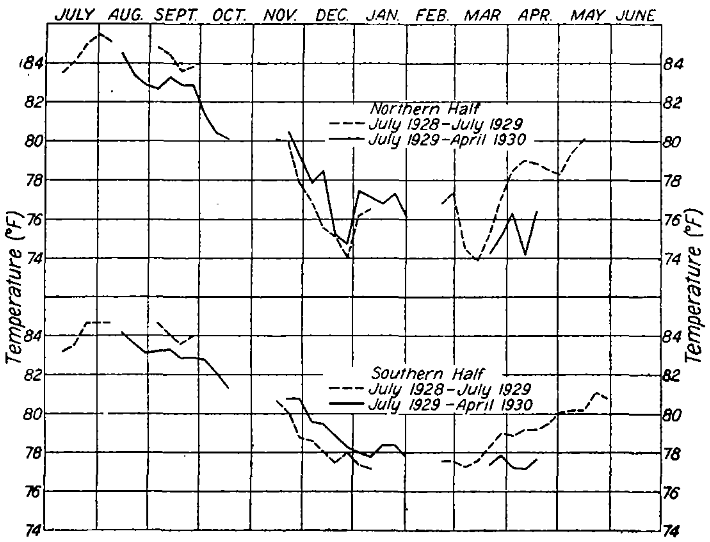

FIGURE 2.—Comparison of Gulf Stream Temperatures (south bound) for two successive years

tures—both daytime and nighttime temperatures for Key West Harbor and the north and south halves of the Straits and daytime temperatures for Habana Harbor. Figure 3 shows the more important of these temperature curves.

As an aid in studying the correspondence between air and sea temperatures as shown by these graphs, the up or down trends of the temperatures from week to week were counted and compared for the period July, 1928, to February, 1930. The number of agreements may be designated by the letter (A). Using the air temperature as a base in each case the number of times that the up or down trends of the sea temperatures agreed with the air temperatures was ascertained; the same was done for different combinations of the sea temperatures. When completed, the following comparisons had been secured.

Maximum air temperatures with daytime temperatures of Key West Harbor, and the north and south halves of the Straits.

Minimum air temperatures with nighttime temperatures of Key West Harbor, and the north and south halves of the Straits.

Mean air temperatures with both day and nighttime temperatures of Key West Harbor and the north and south halves of the Straits.

Both day and nighttime Key West Harbor temperatures with the north and south halves of the Straits.

Both day and nighttime temperatures of the north half with those of the south half of the Straits.

Mean Habana Harbor temperatures (daytime) with maximum air temperatures of the south half of the Straits.

Maximum air temperatures with nighttime temperatures of Key West Harbor and the north and south halves of the Straits.

Table 3 shows the per cent the agreements of the up and down trends actually found, are of the maximum possible number of agreements.[3] The agreements are always well over 50 per cent of the possible and generally over 75 per cent. A study of the table reveals the following general facts: (*a*) the daytime trends generally agree more frequently than the nightime trends; (*b*) the down trends generally agree more frequently than the up trends; and (*c*) the maximum air temperature agrees more frequently with the daytime sea temperature than the minimum air temperature does with the nighttime sea temperature. An explanation for points (*a*) and (*c*) will be brought out in the discussion of Table 4. The truth of point (*b*) depends upon the fact that the winds causing a falling air temperature would have more effect on sea surface temperatures because of convection, than would winds causing a rising air temperature.

In order that the relation between the air and sea temperatures might be expressed conveniently, a percentage relation was obtained and is presented in Table 4. The number of agreements between the up or down trends of each two curves that would occur merely by chance (C) was calculated[4] and the difference between this figure and the actual number of agreements noted was found (A–C). The maximum possible number of agreements

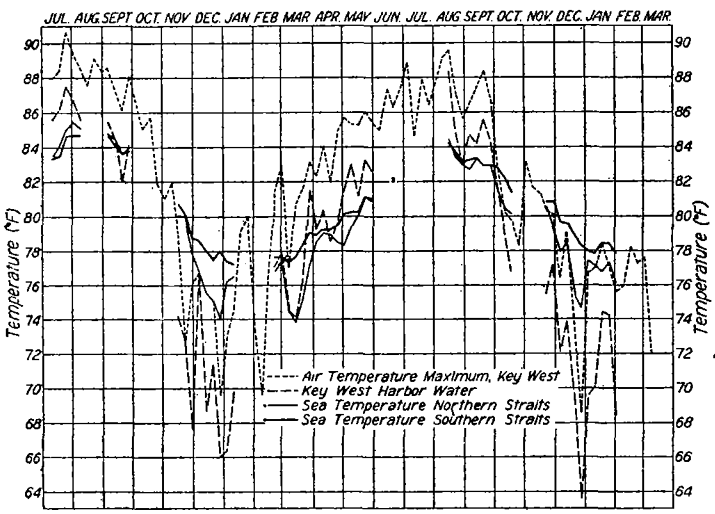

FIGURE 3.—Air, harbor, and Gulf Stream temperatures July, 1928, to March, 1930

was ascertained[3] (M) and the difference between this figure and the chance agreements (M–C) was taken as the hundred per cent which would represent the amount over and above a chance agreement the actual agreements (A) might reach. The ratio between the first difference (A–C) and this figure (M–C), may be taken as a percentage measure of relationship.

The same facts are brought out in this table as in Table 3: (*a*) the agreement between the up or down

[3] The maximum number of agreements possible would be the lesser total of the ups or downs of the two curves.

[4] The number of ups or downs in one curve times the corresponding number in the other curve, divided by the total number of interweekly trends (the number of weeks minus one, plus the number of breaks).

temperature trends for either air and water temperatures or different water temperatures is always above what would be expected merely by chance; (*b*) the nighttime temperatures never have as high an agreement as the daytime temperatures when the comparison is between air and water temperature; (*c*) the maximum air temperature has a percentage of agreement with the daytime sea temperatures more than twice as high as that of the minimum air temperature with the nighttime sea temperatures.

Since the maximum air temperature has the largest percentages of agreement with the ocean temperature it is evident that daytime air temperatures at Key West are a better index to the whole effect of local influences on the temperature of the water than are nighttime Key West temperatures. This is probably because the air minima are less representative of the general air temperature than are the maxima, owing to the less convection at night. Furthermore, the convection set up in the water by the cooling of the surface layer at night would tend to stir the water considerably, thereby operating to prevent its temperature agreement with the air at that time. An explanation for points (*b*) and (*c*) listed in the preceding paragraph and for the similar points (*a* and *c*) in the discussion of Table 3, may be based on this conclusion.

The highest percentage of agreements in excess of what would be expected by chance occurs between the air temperatures and the Key West Harbor temperatures, as would be expected. The air temperature has a high agreement also with the north half of the Straits, though much less than with Key West Harbor, and a fairly high agreement even with the south half of the Straits.

While the foregoing discussion seems adequate to indicate the rather close relation between the temperature of air and shallow waters here, a detailed study may be made from the very complete data compiled by Dr. Wayland Vaughan (*2*). His paper includes weekly air temperatures at Tortugas from June, 1912, to June, 1913, and surface water temperatures at various stations about Fort Jefferson, taken at 7 a. m. and 3 p. m. from June, 1911, to June, 1912, with air temperatures for the same hours from January, 1912, to June, 1912. Temperature reductions to means of 10-day periods from observations made by the keepers of lighthouses along the Florida reefs for varying periods of years (generally 1878 to 1890) are also included. The stations are Dry Tortugas, Key West, Carysfort Reef, and Fowey Rocks. Mean air temperature at Key West could be used in connection with these sea temperatures in studying the relation between air and sea temperature fluctuations.

In the year and a half for which sea water thermograms have been obtained and subjected to close study there have occurred two general down-trends of temperature (September, 1928, to March, 1929, and August, 1929, to February, 1930) and only one up-trend (March to August, 1929, and a very short upward record in July and August, 1928). A smooth curve then would be represented by twice as many downs as ups and, except at the three turning points, each down trend should be followed by a down trend and each up trend by another up trend. Table 5 shows what was actually found to be the case.

The Key West and Habana Harbors show the lowest per cent of continuity of temperature trend, even lower than the air temperatures. Though this may appear to be an anomaly, it might well be expected in this case inasmuch as the harbor temperatures were reported at different hours in different weeks, and particularly, were more subject to irregular extremes resulting from mixing of outtake waters with the intake around the docks, and from winds blowing the warm surface waters on-shore or off-shore.

The nighttime Gulf Stream temperatures show the greatest continuity of trend, the nighttime air temperatures the least. The nighttime air temperatures are minimum air temperatures, which, being under considerable local control in quiet weather, tend to follow a very zigzag course from week to week. At nighttime, the water, however, being more stirred by convection, takes on the temperature of a larger mass than just the surface layer and so tends to be fairly stable in its general course of temperature. Consequently the highest percentages of continuity occur in the sea-water temperatures and these at night.

Though continuity of trend in the south half of the Straits is not outstanding, the graphs show readily that the up and down fluctuations are so small that the temperature curve appears by far the smoothest. In Table 5 the high percentage of "steady" temperature trends, especially in the nighttime temperatures, indicates that the general curve should be fairly smooth.

RELATION OF GULF STREAM TEMPERATURES IN THE STRAITS OF FLORIDA TO THOSE FARTHER TO THE NORTHEAST

A thermal index.—It must not be overlooked that the temperatures of the surface of the Gulf Stream in the Straits of Florida here presented are simply surface temperatures of a faster or slower, more turbulent or less turbulent, stream as it passes a certain line near the entrance to the Straits. In summer, Harvey (**3**) has found that times of light winds and little turbulence will be marked by higher surface temperatures, though less storage of heat, than will periods of stronger winds and more turbulence. Thus higher summer temperatures are likely to mean lower heat deliveries and, therefore, lower surface temperatures later farther along in the Gulf Stream. Nevertheless, a surface layer of unusually warm water may not have an opportunity to dissipate its heat by evaporation and radiation, as it would ordinarily do rapidly, for a hurricane, or even a gale, may stir it into a deep body of water, reducing the surface temperature so that the heat will be conserved till farther than usual along the course of the stream. British investigators might, in consequence, expect higher temperatures in the eastern North Atlantic some months after a period of numerous West Indian hurricanes. If the hurricanes occurred mostly east of Key West the variations of Gulf Stream temperatures near Key West might have no apparent relation to those of the same water later observed two or three thousand miles along its course. Herein lies the importance of recording the temperatures, as it is now being done (**4**), across the Stream on several lines after the Gulf Stream leaves the Straits. Therefore, these tables are presented simply for what they are. It is hoped, through the navigational record of the car ferries, to get some knowledge of the current each day, and thus, with the temperatures, to provide some index to the thermal cargo carried.

TABLE 1.—*Average weekly temperature values for Key West and Habana Harbors, extremes from the harbors to the sea buoys, and means by twelfths across the Straits of Florida, July 1928 to February 1930*

	Key West Harbor	Key West—Sea buoy		1	2	3	4	5	6	7	8	9	10	11	12	Sea buoy—Habana		Habana Harbor
		Maximum	Minimum													Minimum	Maximum	
1928																		
July 9-14	85.6	85.7	84.3	83.8	83.6	83.5	83.5	83.5	83.3	83.1	83.0	83.2	83.4	83.4	83.2	82.4	86.6	83.7
July 15-21	86.2	86.1	83.7	83.6	83.9	84.1	84.2	84.1	84.2	83.9	83.7	83.5	83.2	83.1	82.5	82.1	85.0	83.5
July 22-28	87.5	88.0	85.2	85.0	84.8	84.8	85.2	85.2	85.2	85.0	84.8	84.6	84.5	84.2	83.1	82.7	85.3	84.1
July 29-Aug. 4	86.7	88.9	85.6	85.5	85.6	85.6	85.5	85.4	85.3	85.2	84.9	84.6	84.4	84.4	84.2	83.3	86.6	84.6
Aug. 5-11 [1]	85.6	85.7	85.0	85.1	85.1	85.0	85.1	85.0	85.0	84.8	84.7	84.5	84.8	84.9	84.6	83.9	86.9	85.0
Sept. 3-9	85.5	85.9	84.8	85.1	85.1	85.0	84.7	84.5	84.5	84.7	84.7	84.8	84.7	84.5	83.9	83.1	86.1	84.1
Sept. 10-16	84.5	84.7	84.1	84.4	84.4	84.5	84.5	84.4	84.2	84.2	84.1	84.1	84.1	84.1	84.0	83.8	85.9	84.6
Sept. 17-23	82.0	82.4	81.6	83.2	83.6	83.6	83.6	83.6	83.4	83.4	83.7	83.7	83.6	83.6	83.6	83.3	84.7	84.2
Sept. 24-30 [2]	84.2	84.3	83.5	83.9	84.0	84.0	83.9	83.7	83.6	83.7	83.9	84.1	84.1	84.0	83.7	83.4	85.8	84.4
Nov. 12-18	74.2	78.3	73.8	78.9	79.3	79.8	80.4	80.5	80.6	80.7	80.7	80.7	80.7	80.8	80.3	78.4	80.0	79.8
Nov. 19-25	72.8	76.5	70.0	78.8	79.5	79.8	80.1	80.3	80.3	80.4	80.2	80.0	80.0	80.0	79.8	77.5	80.1	78.1
Nov. 26-Dec. 2	67.6	77.0	67.3	77.4	77.6	77.9	77.8	77.8	78.3	78.3	78.7	78.9	79.1	79.2	79.0	74.1	78.8	74.8
Dec. 3-9	76.9	77.4	76.4	77.0	77.1	77.0	76.6	76.6	77.2	77.9	77.9	78.4	79.5	79.6	79.5	77.2	78.4	77.5
Dec. 10-16	68.6	74.3	67.8	75.4	75.8	75.5	75.4	75.3	75.6	76.6	77.2	78.3	78.9	79.0	78.8	74.8	78.4	75.4
Dec. 17-23	71.5	75.0	71.3	75.3	74.9	74.8	74.8	74.8	76.0	76.6	76.8	77.7	78.3	78.3	78.2	75.5	76.9	76.8
Dec. 24-31	66.0	72.7	66.5	73.2	73.4	73.5	73.7	73.2	76.5	77.7	78.1	78.2	77.9	77.9	77.8	73.2	77.4	74.4
1929																		
Jan. 1-7	66.4	72.6	65.1	73.0	74.0	75.7	76.8	77.1	77.2	77.4	77.4	77.5	77.4	77.4	77.3	74.7	77.2	74.8
Jan. 8-14 [3]	69.8	73.3	68.5	73.6	75.3	76.4	76.7	77.0	77.1	77.2	77.3	77.2	77.2	77.2	77.3	75.2	77.0	76.0
Feb. 19-25	77.1	77.1	74.6	75.2	75.4	76.2	77.4	77.4	77.5	77.5	77.6	77.5	77.6	77.6	77.4	77.1	79.0	78.2
Feb. 26-Mar. 3	77.9	77.8	75.5	76.2	76.9	77.4	77.6	77.6	77.5	77.6	77.6	77.6	77.6	77.5	77.4	77.4	78.9	77.7
Mar. 4-10	74.5	75.6	72.5	73.5	73.9	73.9	73.8	76.4	76.4	77.3	77.4	77.4	77.2	77.1	77.0	76.7	78.0	77.3
Mar. 11-17	74.1	73.9	72.9	73.2	73.1	72.7	73.0	73.9	76.2	77.4	77.6	77.7	77.6	77.5	77.1	76.4	77.2	77.2
Mar. 18-24	76.3	76.6	75.5	75.8	75.2	75.0	74.6	74.9	76.2	78.0	78.3	78.4	78.5	78.6	78.4	78.1	79.6	79.0
Mar. 25-31	81.6	81.4	77.7	77.1	76.4	75.8	76.2	78.3	79.1	79.2	79.2	79.0	78.9	78.8	79.0	78.8	80.9	79.8
Apr. 1-7	79.2	79.5	77.7	76.9	77.2	78.1	78.9	79.2	79.1	79.1	79.0	78.9	78.8	78.8	78.7	78.4	80.4	79.9
Apr. 8-14	80.4	80.2	78.2	77.9	78.0	78.6	79.4	79.5	79.4	79.4	79.3	79.2	79.2	79.0	78.9	78.8	80.6	79.6
Apr. 15-21	77.5	78.1	75.7	76.9	78.2	78.8	79.0	79.1	79.2	79.2	79.2	79.2	79.2	79.2	79.3	79.3	80.7	80.3
Apr. 22-28	79.6	79.5	77.2	78.2	78.6	78.2	78.3	78.6	78.8	79.2	79.5	79.6	79.6	79.5	79.5	79.6	81.5	80.0
Apr. 29-May 5	81.5	82.4	79.4	78.4	78.2	78.2	78.2	78.1	78.7	79.5	80.2	80.3	80.3	80.4	80.3	80.0	82.8	81.2
May 6-12	83.0	82.5	79.8	79.6	79.2	79.0	79.0	79.9	80.1	80.3	80.3	80.2	80.2	80.1	80.0	79.8	83.2	81.8
May 13-19	81.1	81.1	79.5	79.4	79.5	79.9	80.3	80.3	80.3	80.4	80.4	80.3	79.9	79.8	79.3	78.7	82.0	80.6
May 20-26	83.3	83.4	80.7	80.5	80.5	81.0	81.2	81.4	81.3	81.2	81.2	81.1	81.0	80.9	80.7	80.1	82.8	81.3
May 27-June 2 [4]	82.6	82.5	80.6	80.6	80.6	80.7	81.1	81.3	81.3	80.9	80.7	80.8	80.7	80.8	80.7	80.0	83.3	80.0
June 17-23 [5]	83.6	83.5	81.7	81.5	81.5	81.8	82.1	82.1	82.3	82.4	82.3	82.1	81.9	81.9	81.8	81.3	83.9	82.5
July 1-7 [6]	88.3	88.6	83.0	83.4	83.3	83.2	83.1	83.0	82.8	82.9	83.0	82.9	82.8	82.8	82.7	82.7	87.0	83.9
Aug. 12-18	88.4	88.5	85.0	84.9	84.7	84.5	84.4	84.5	84.3	84.2	84.2	84.2	84.2	84.2	84.2	83.5	86.7	84.6
Aug. 19-25	84.9	85.3	83.9	83.8	83.6	83.3	83.1	83.3	83.5	83.6	83.7	83.6	83.6	83.3	82.7	82.5	85.2	83.7
Aug. 26-Sept. 2	83.0	83.3	81.9	82.8	82.9	83.0	82.8	82.8	82.9	83.0	83.1	83.3	83.2	83.1	82.8	81.6	84.0	82.7
Sept. 3-9	84.8	84.6	83.0	83.0	82.8	82.6	82.6	82.6	83.0	83.2	83.1	83.2	83.2	83.2	83.2	82.3	86.2	83.8
Sept. 10-16	84.2	84.5	83.6	83.4	83.6	83.4	83.2	83.1	83.1	83.2	83.3	83.3	83.4	83.3	83.3	82.8	85.6	83.8
Sept. 17-23	85.6	85.6	83.4	83.4	83.2	83.0	82.9	82.7	82.6	82.6	82.9	83.1	83.0	83.0	83.0	82.6	85.3	83.6
Sept. 24-30	84.3	86.0	82.6	82.5	82.6	83.3	83.2	82.7	82.6	82.5	82.7	82.8	83.0	83.2	83.1	83.3	85.2	84.3
Oct. 1-7	81.8	81.8	81.0	81.3	81.5	81.4	81.6	80.6	81.8	82.5	82.7	82.9	82.8	82.9	83.1	83.5	85.4	84.8
Oct. 8-14	79.4	81.0	78.7	80.1	79.1	79.2	80.4	81.5	82.0	82.0	82.1	82.1	82.1	82.1	82.2	81.8	83.8	83.0
Oct. 15-21 [7]	76.8	77.8	76.6	78.6	78.8	78.9	80.2	81.3	81.4	81.3	81.2	81.3	81.5	81.3	81.1	91.1	83.0	82.4
Nov. 19-25	75.5	78.5	75.3	79.2	79.7	80.3	80.7	81.0	81.0	80.9	80.8	80.8	80.7	80.7	80.6	79.4	80.1	80.3
Nov. 26-Dec. 2	77.2	77.8	76.6	77.5	77.4	77.5	79.9	80.8	81.0	80.9	80.9	80.9	80.8	80.7	80.4	79.4	82.6	80.8
Dec. 3-9	72.1	74.0	71.7	75.1	75.4	75.9	78.7	79.6	79.7	79.6	79.6	79.6	79.7	79.6	79.7	78.3	80.4	79.2
Dec. 10-16	73.9	76.9	73.0	76.7	77.3	77.0	79.0	79.6	79.5	79.5	79.5	79.5	79.5	79.4	79.4	78.4	80.5	79.3
Dec. 17-23	69.5	75.2	69.3	75.0	75.8	74.9	74.2	75.2	75.6	78.5	78.9	79.2	79.0	78.9	78.7	75.5	78.6	77.2
Dec. 24-31	63.6	73.6	61.9	73.8	73.7	73.4	74.3	75.3	76.7	77.9	78.2	78.4	78.4	78.4	78.2	73.4	76.3	76.6
Jan. 1-7	69.5	74.0	67.7	74.2	75.4	77.0	78.0	78.2	78.2	78.2	78.1	78.0	78.0	77.9	77.7	74.8	77.8	75.8
Jan. 8-14	70.1	75.4	69.6	75.9	76.1	76.3	77.2	77.9	77.9	78.0	77.8	77.7	77.7	77.7	77.6	74.9	77.4	75.8
Jan. 15-21	74.4	74.3	73.6	74.0	73.9	76.2	77.8	78.0	78.3	78.7	78.7	78.4	78.2	78.2	77.6	75.6	78.2	77.6
Jan. 22-28	74.2	75.3	73.1	75.2	75.9	76.5	77.4	78.3	78.4	78.4	78.5	78.5	78.5	78.4	77.9	76.8	79.2	77.9
Jan. 29-Feb. 4 [8]	68.4	73.3	69.6	73.5	74.0	75.2	76.3	77.5	77.6	77.8	77.8	77.8	77.8	77.8	77.7	75.6	77.5	76.2
Mar. 11-17 [9]	75.6	74.5	72.4	74.3	74.4	73.3	73.4	73.0	75.4	77.3	77.7	77.9	77.6	77.6	77.7	77.0	80.0	77.7
Mar. 18-24	77.5	76.6	74.4	75.1	74.8	74.7	74.5	75.1	76.1	77.1	78.1	78.4	78.4	78.3	78.2	78.0	79.9	78.7
Mar. 25-31	74.5	75.9	72.5	73.4	73.5	73.6	74.4	75.4	77.1	77.8	78.0	78.2	78.3	78.3	78.3	78.1	79.3	78.8
Apr. 1-7	76.7	77.8	73.7	74.5	74.7	75.6	76.7	77.8	78.0	78.0	77.9	77.8	77.7	77.6	77.7	77.6	80.0	78.3
Apr. 8-14	74.1	74.6	72.7	74.5	74.1	73.6	73.9	73.8	76.3	77.7	77.8	77.8	77.8	77.7	77.7	76.9	79.0	78.4
Apr. 15-21	79.1	79.5	75.5	75.4	75.3	76.2	67.8	77.6	78.6	78.6	78.5	78.3	78.3	78.2	78.2	77.8	80.5	78.7
Apr. 22-28	78.8	79.2	77.2	77.7	77.9	78.3	78.2	78.4	78.6	79.3	79.7	79.7	79.5	79.0	78.8	78.4	81.0	79.5
Apr. 29-May 5	79.8	80.1	78.5	78.3	78.1	77.8	77.5	77.5	78.4	79.4	79.7	79.6	79.5	79.3	79.3	79.2	83.3	80.6
May 6-12	80.5	80.6	79.0	78.4	78.1	78.3	78.7	79.5	80.0	80.4	80.4	80.3	80.1	79.7	79.3	79.1	82.5	80.8
May 13-19	82.8	83.4	79.9	79.7	79.7	79.9	80.4	81.2	80.9	80.9	80.9	80.7	80.7	80.9	80.8	80.5	84.2	81.7
May 20-26	84.4	84.4	81.3	81.6	82.0	82.1	82.0	81.9	81.9	81.9	81.9	81.7	81.6	81.3	80.7	79.9	83.4	81.7
May 27-June 2	82.9	83.0	80.7	81.1	80.9	81.0	80.8	81.0	81.1	81.3	81.6	81.4	81.6	81.7	81.7	80.0	82.3	80.8
June 3-9	79.1	79.5	78.1	79.5	79.6	79.3	79.8	80.3	80.3	80.5	80.7	80.7	80.9	80.9	81.2	81.3	82.7	81.3

[1] Aug. 19 to Sept. 2, 1928. No record; ship in port.
[2] Oct. 1 to Nov. 11, 1928. No record; ship in port.
[3] Jan. 15 to Feb. 18, 1929. No record; ship in port.
[4] June 3 to June 16, 1929. No record; ship in port.
[5] June 24 to June 30, 1929. No record; ship in port.
[6] July 8 to Aug. 11, 1929. No record; ship in port.
[7] Oct. 22 to Nov. 18, 1929. No record; ship in port.
[8] Feb. 5 to Mar. 10, 1930. No record; ship in port,
[9] Record for 1 day only in this week,

TABLE 1.—*Average weekly temperature values for Key West and Habana Harbors, extremes from the harbors to the sea buoys, and means by twelfths across the Straits of Florida, July 1928 to February 1930*—Continued

1928	Habana harbor	Habana to Sea buoy		12	11	10	9	8	7	6	5	4	3	2	1	Sea buoy to Key West		Key West harbor
		Maximum	Minimum													Minimum	Maximum	
July 9-14	83.6	85.8	83.2	83.4	83.6	83.5	83.4	83.2	83.3	83.7	83.9	84.1	84.1	84.1	84.2	84.0	86.3	85.8
July 15-21	83.5	85.1	82.5	82.5	82.9	83.4	83.6	83.9	84.2	84.4	84.4	84.5	84.3	84.3	84.1	83.8	86.5	86.2
July 22-28	84.5	85.0	82.0	83.5	84.9	84.9	84.8	85.4	85.7	86.0	86.2	86.5	86.6	85.9	85.7	87.0	88.5	88.3
July 29-Aug. 4	84.9	86.3	83.6	84.2	84.5	84.7	84.8	85.1	85.5	85.7	85.9	85.9	85.9	86.0	86.0	85.8	87.7	87.0
Aug. 5-11 [10]	85.0	87.1	84.4	85.1	85.2	84.8	84.9	85.3	85.3	85.4	85.5	85.4	85.3	85.3	85.3	85.3	86.2	85.2
Sept. 3-9	84.0	85.8	83.2	84.1	84.6	84.8	84.8	84.7	84.7	84.7	84.7	84.9	85.2	85.4	85.4	84.8	86.0	85.2
Sept. 10-16	84.7	85.4	83.7	84.1	84.1	84.1	84.2	84.3	84.1	84.3	84.6	84.6	84.6	84.6	84.5	84.1	85.0	84.4
Sept. 17-23	84.4	85.3	83.7	83.7	83.7	83.9	83.8	83.5	83.6	83.8	83.9	83.9	83.8	83.8	83.2	81.9	82.8	81.9
Sept. 24-30 [11]	84.4	85.8	83.7	84.0	84.2	84.4	84.3	84.2	84.1	84.1	84.4	84.6	84.7	84.7	84.7	84.0	85.7	85.5
Nov. 12-18	79.8	80.2	79.0	80.2	80.4	80.5	80.5	80.5	80.5	80.5	80.4	80.3	80.0	79.4	78.7	72.7	78.3	74.0
Nov. 19-25	78.2	79.9	77.6	80.1	80.2	80.3	80.4	80.4	80.4	80.4	80.3	80.2	80.1	79.8	78.7	71.6	77.7	71.9
Nov. 26-Dec. 2	74.8	78.5	74.4	79.0	79.2	79.2	78.9	78.5	78.1	78.0	78.0	77.8	77.7	77.5	77.4	68.3	76.9	68.4
Dec. 3-9	76.5	79.1	76.4	79.4	79.9	79.7	79.1	78.6	78.6	78.0	77.5	77.3	77.4	77.3	77.0	75.4	77.8	76.0
Dec. 10-16	75.4	77.6	75.0	78.6	79.0	78.6	78.2	77.5	76.8	76.1	75.4	75.6	75.7	75.8	76.0	67.9	75.2	69.5
Dec. 17-23	76.8	77.7	76.0	78.3	78.5	78.6	77.9	77.3	77.1	74.7	74.6	74.7	74.7	74.7	75.0	70.6	74.3	71.2
Dec. 24-31	74.5	77.4	73.6	77.8	78.0	78.1	78.3	78.1	77.5	76.0	74.3	74.0	73.5	73.3	73.0	65.0	72.6	65.4
1929																		
Jan. 1-7	74.5	76.9	74.8	77.4	77.5	77.6	77.7	77.6	77.3	77.2	77.2	77.0	75.6	74.3	74.3	66.4	73.8	66.7
Jan. 8-14 [12]	75.2	77.0	75.7	77.3	77.3	77.3	77.4	77.4	77.3	77.0	76.9	76.7	76.4	75.4	73.9	68.5	73.4	71.5
Feb. 19-25	78.0	79.3	77.8	77.6	77.8	77.8	77.8	77.7	77.8	77.9	77.8	77.5	76.8	76.2	75.6	75.5	78.2	77.8
Feb. 26-Mar. 3	78.6	78.9	77.9	77.7	77.9	78.1	78.2	78.2	78.1	78.0	77.9	77.7	77.4	76.7	76.0	76.0	78.9	77.9
Mar. 4-10	77.3	78.2	76.0	77.2	77.4	77.6	77.6	77.6	77.1	75.9	74.6	74.1	73.9	73.9	73.6	72.8	75.2	74.5
Mar. 11-17	77.2	77.7	76.8	77.2	77.6	77.7	77.9	77.8	77.6	77.1	75.9	74.0	73.5	73.9	73.8	73.4	75.4	74.1
Mar. 18-24	79.2	80.2	78.5	78.9	79.0	79.2	79.2	79.1	78.5	77.4	76.0	76.0	75.8	75.9	76.2	75.7	77.6	77.0
Mar. 25-31	79.8	80.7	79.0	78.9	79.1	79.2	79.4	79.4	79.4	79.2	78.3	76.7	67.8	77.4	78.0	79.1	82.2	81.6
Apr. 1-7	79.3	80.2	78.9	78.9	79.0	79.0	79.2	79.4	79.4	79.4	79.2	78.8	78.0	77.0	77.0	77.1	79.1	80.2
Apr. 8-14	79.6	80.7	79.2	79.5	79.8	79.8	79.9	80.1	80.3	80.3	80.2	80.1	79.5	78.8	78.4	78.8	82.4	80.4
Apr. 15-21	80.3	81.3	79.6	79.5	79.5	99.4	79.3	79.3	79.3	79.2	79.1	79.0	78.8	78.2	77.3	75.5	78.1	77.5
Apr. 22-28	80.3	81.8	79.8	79.9	80.1	80.3	80.4	80.4	80.2	79.9	79.8	79.7	79.4	79.0	78.8	79.1	82.2	81.1
Apr. 29-May 5	81.0	82.8	80.3	80.7	80.8	80.8	80.7	80.6	79.9	79.5	79.2	79.2	79.1	79.0	79.1	78.4	82.2	81.5
May 6-12	81.3	82.8	80.4	80.2	80.3	80.3	80.4	80.4	80.4	80.4	80.2	79.7	79.6	79.5	79.7	80.2	82.9	81.8
May 13-19	80.7	82.0	79.0	79.6	80.0	80.3	80.6	80.7	80.7	80.7	80.6	80.4	80.2	79.9	79.6	79.6	81.3	81.3
May 20-26	81.6	82.9	80.6	81.1	81.6	81.9	81.8	81.8	81.8	81.8	81.7	81.5	81.1	80.8	80.8	81.2	84.1	83.3
May 27-June 2 [13]	82.2	83.1	80.1	80.7	81.0	80.9	81.0	81.0	81.1	81.2	81.4	81.3	81.2	80.9	80.9	80.7	82.2	82.5
June 17-23 [14]	82.5	84.8	81.5	82.3	82.5	82.6	82.7	82.8	82.8	82.6	82.4	82.2	81.9	81.9	81.9	82.2	84.3	84.1
July 1-7 [15]	84.0	86.4	82.6	83.0	83.2	83.3	83.4	83.6	83.6	83.7	84.0	84.1	84.2	84.2	84.2	83.8	90.0	89.0
Aug. 12-18	84.6	86.7	83.9	84.5	84.6	84.7	84.6	84.7	84.8	85.0	85.2	85.2	85.3	85.5	85.7	85.6	88.9	88.3
Aug. 19-25	83.6	85.8	82.2	83.1	83.8	84.0	83.9	83.9	83.8	83.8	83.6	83.6	83.7	84.0	84.1	84.3	86.0	85.3
Aug. 26-Sept. 2	83.0	83.9	82.5	83.1	83.4	83.5	83.6	83.5	83.4	83.3	83.3	83.5	83.5	83.4	83.2	82.3	84.1	83.1
Sept. 3-9	84.0	84.7	83.0	83.4	83.4	83.6	83.5	83.4	83.4	84.3	83.3	83.5	83.4	83.4	83.4	83.4	85.4	84.8
Sept. 10-16	84.0	84.9	83.4	83.5	83.5	83.6	83.5	83.6	83.6	83.6	83.5	83.7	84.0	84.1	84.1	84.0	85.4	84.5
Sept. 17-23	84.0	85.9	83.2	83.6	83.8	83.8	83.7	83.6	83.5	83.4	83.4	83.8	83.9	84.0	84.0	84.0	86.0	85.7
Sept. 24-30	84.2	85.2	83.2	83.3	83.4	83.3	83.2	82.9	82.6	82.7	83.1	83.4	83.1	83.0	82.9	83.1	84.9	84.5
Oct. 1-7	85.0	85.5	83.0	82.8	82.7	82.8	82.8	82.8	82.6	81.8	81.6	81.6	81.6	80.9	81.3	80.0	81.5	80.5
Oct. 8-14	83.0	83.6	81.9	82.1	82.0	81.9	82.0	82.1	82.2	82.1	81.8	81.1	79.5	79.6	79.7	78.0	79.4	78.2
Oct. 15-21 [16]	82.5	83.8	81.2	81.4	81.4	81.5	81.4	81.2	81.5	81.6	81.2	79.9	78.7	78.9	78.6	76.7	77.6	77.1
Nov. 19-25	80.5	80.1	79.9	80.5	80.8	80.9	80.9	81.0	81.0	80.9	80.9	80.7	80.1	79.5	78.3	75.2	76.8	75.3
Nov. 26-Dec. 2	80.8	81.8	80.1	80.6	80.8	81.0	81.0	81.1	81.1	81.0	80.6	79.2	77.7	77.7	77.8	76.6	78.0	77.2
Dec. 3-9	79.1	80.1	78.6	79.8	79.8	79.7	79.6	79.6	79.6	79.7	79.3	77.2	76.3	75.8	74.9	67.6	74.2	71.9
Dec. 10-16	79.4	79.9	78.9	79.6	79.5	79.5	79.5	79.5	79.4	79.6	79.6	79.2	78.6	77.4	76.8	73.4	76.8	74.0
Dec. 17-23	77.2	78.5	75.7	78.6	78.8	78.9	79.0	79.0	78.8	77.0	75.2	73.6	75.2	75.6	75.0	66.6	70.0	67.8
Dec. 24-31	76.6	77.5	74.0	78.2	78.3	78.3	78.3	78.2	77.9	77.0	74.8	73.7	73.1	73.4	73.9	61.6	73.5	63.6
Jan. 1-7	75.8	77.7	75.1	77.8	78.0	78.1	78.0	78.1	78.2	78.3	78.1	77.5	76.4	76.1	74.3	68.8	73.1	69.5
Jan. 8-14	75.8	77.4	75.5	77.6	77.8	77.7	77.7	77.9	78.1	78.2	77.7	77.0	76.8	76.5	75.7	70.4	75.7	70.1
Jan. 15-21	77.9	77.8	76.4	78.0	78.4	78.7	79.0	79.0	78.8	78.3	77.8	76.9	74.4	74.0	74.8	74.2	75.4	74.1
Jan. 22-28	77.9	78.8	77.3	78.0	78.4	78.6	78.6	78.7	78.7	78.5	78.4	77.9	76.9	76.0	75.6	74.0	75.3	74.1
Jan. 29-Feb. 4	76.3	77.3	76.0	77.8	77.8	77.9	77.8	77.7	77.8	77.8	77.6	76.4	75.4	74.2	74.0	70.0	73.0	70.8
Mar. 11-17	77.6	79.4	77.2	77.7	77.6	77.5	77.9	77.8	77.6	75.0	72.2	73.3	73.7	74.7	74.9	74.1	76.6	74.1
Mar. 18-24	78.7	80.1	78.2	78.6	78.9	79.1	79.3	79.1	78.2	77.5	76.6	75.8	75.5	75.7	76.0	75.5	78.6	77.7
Mar. 25-31	78.6	79.3	78.0	78.2	78.1	78.1	78.2	78.3	77.9	77.2	76.2	74.7	74.4	74.2	74.2	72.7	75.4	73.8
Apr. 1-7	78.4	79.4	77.7	77.9	77.8	77.8	78.0	78.3	78.3	78.2	78.0	76.8	75.9	75.7	75.0	74.0	76.9	76.6
Apr. 8-14	78.6	79.3	77.4	77.7	77.9	77.9	77.9	78.0	78.0	77.6	76.4	75.4	75.0	74.6	74.5	73.2	75.3	73.7
Apr. 15-21	78.7	80.5	77.9	78.2	78.5	78.7	78.8	79.1	79.3	79.2	78.8	78.5	78.2	77.0	76.2	76.3	80.4	78.8
Apr. 22-28	79.5	81.0	78.6	79.1	79.3	79.5	80.0	80.2	80.1	79.5	79.0	78.4	78.4	78.3	78.1	77.9	79.6	79.2
Apr. 29-May 5	81.0	82.9	79.3	79.8	79.9	80.0	80.3	80.3	79.9	78.8	78.3	78.3	78.7	78.6	79.0	79.1	81.3	80.7
May 6-12	81.2	82.4	79.2	79.5	79.9	80.3	80.5	80.7	80.6	80.4	79.7	79.2	78.9	78.7	78.7	79.6	81.0	80.7
May 13-19	82.0	84.2	80.8	81.3	81.6	81.7	81.6	81.8	82.0	81.9	81.6	81.3	81.0	80.6	80.4	80.7	85.2	84.3
May 20-26	82.2	83.5	80.0	80.5	81.1	81.7	82.1	82.4	82.6	82.5	82.6	82.6	82.5	82.4	82.0	81.1	84.5	84.3
May 27-June 2	80.9	82.2	80.2	81.3	81.9	82.2	82.3	82.2	82.1	81.9	81.7	81.6	81.5	81.5	81.4	81.0	82.8	83.4
June 3-9	81.9	83.3	81.3	81.5	81.3	81.2	81.3	81.3	81.1	80.7	80.5	80.3	79.7	79.7	79.5	78.5	79.5	78.7

[10] Aug. 19 to Sept. 2, 1928. No record; ship in port.
[11] Oct. 1 to Nov. 11, 1928. No record; ship in port.
[12] Jan. 15 to Feb. 18, 1929. No record; ship in port.
[13] June 3 to June 16, 1929. No record; ship in port.
[14] June 24 to June 30, 1929. No record; ship in port.
[15] July 8 to Aug. 11, 1929. No record; ship in port.
[16] Oct. 22 to Nov. 18, 1929. No record; ship in port.

TABLE 2.—*Average weekly temperature values by quarters and halves across the Straits of Florida, July, 1928, to February, 1930*

	Key West-Habana 1	2	3	4	N.	S.	Habana-Key West S.	N.	4	3	2	1
1928												
July 8-14	83.6	83.4	83.0	83.3	83.5	83.2	83.4	84.0	83.5	83.3	83.9	84.1
July 15-21	83.9	84.2	83.8	83.0	84.1	83.5	83.6	84.4	82.9	83.9	84.4	84.2
July 22-28	84.8	85.2	84.8	84.0	85.0	84.7	85.1	86.2	84.4	85.3	86.2	86.1
July 29-Aug. 4	85.6	85.4	84.9	84.4	85.5	84.7	84.9	85.9	84.5	85.1	85.8	86.0
Aug. 5-11 [1]	85.1	85.1	84.7	84.8	85.1	84.7	85.1	85.4	85.1	85.2	85.5	85.3
Sept. 3-9	85.1	84.6	84.7	84.4	84.8	84.7	84.7	85.0	84.5	84.8	84.7	85.3
Sept. 10-16	84.4	84.4	84.1	84.1	84.4	84.1	84.2	84.6	84.1	84.2	84.5	84.6
Sept. 17-23	83.5	83.5	83.6	83.6	83.6	83.6	83.7	83.8	83.8	83.6	83.9	83.6
Sept. 24-30 [2]	84.0	83.7	83.9	84.0	83.8	84.0	84.2	84.5	84.2	84.2	84.4	84.7
Nov. 12-18	79.3	80.5	80.7	80.6	80.1	80.7	80.5	80.1	80.4	80.5	80.4	79.3
Nov. 19-25	79.4	80.2	80.2	80.0	80.0	80.1	80.4	80.1	80.2	80.4	80.3	79.5
Nov. 26-Dec. 2	77.6	77.9	78.7	79.1	77.9	78.8	78.8	77.8	79.2	78.5	78.0	77.5
Dec. 3-9	77.0	76.8	78.1	79.5	76.9	78.6	79.2	77.5	79.6	78.8	77.5	77.2
Dec. 10-16	75.6	75.4	77.3	78.9	75.5	78.0	78.0	75.7	78.7	77.5	75.7	75.8
Dec. 17-23	75.0	75.2	77.0	78.3	75.1	77.5	77.9	74.7	78.5	77.4	74.7	74.8
Dec. 24-31	73.4	74.5	78.0	77.9	74.0	78.0	78.0	74.2	78.0	77.9	74.8	73.3
1929												
Jan. 1-7	74.2	77.0	77.4	77.4	76.2	77.4	77.5	76.3	77.5	77.5	77.1	74.7
Jan. 8-14 [3]	75.1	76.9	77.2	77.2	76.5	77.2	77.3	76.5	77.3	77.3	76.9	75.2
Feb. 19-25	75.6	77.5	77.5	77.5	76.8	77.6	77.8	77.2	77.8	77.8	77.8	76.2
Feb. 26-Mar. 3	76.8	77.6	77.6	77.5	77.4	77.6	78.1	77.5	77.9	78.1	77.9	76.7
Mar. 4-10	73.8	75.0	77.4	77.1	74.5	77.3	77.4	74.5	77.4	77.4	74.9	73.8
Mar. 11-17	73.0	74.4	77.6	77.4	73.8	77.6	77.7	74.9	77.5	77.8	75.6	73.7
Mar. 18-24	75.4	75.2	78.2	78.5	75.2	78.3	79.0	76.2	79.0	78.9	76.5	76.0
Mar. 25-31	76.4	77.8	79.1	78.9	77.1	79.0	79.3	77.7	79.1	79.4	78.1	77.4
Apr. 1-7	77.4	79.1	79.0	78.7	78.5	78.9	79.2	78.5	78.9	79.3	79.1	77.3
Apr. 8-14	78.2	79.4	79.3	79.0	79.0	79.2	80.0	79.8	79.7	80.1	80.2	78.9
Apr. 15-21	78.0	79.1	79.2	79.3	78.9	79.2	79.4	78.9	79.5	79.3	79.1	78.1
Apr. 22-28	78.3	78.6	79.4	79.5	78.5	79.5	80.3	79.6	80.1	80.3	79.8	79.1
Apr. 29-May 5	78.3	78.4	80.0	70.3	78.3	80.1	80.6	79.2	80.8	80.4	79.3	79.0
May 6-12	79.2	79.7	80.2	80.1	79.4	80.2	80.4	79.9	80.3	80.4	80.1	79.6
May 13-19	79.6	80.3	80.3	79.7	80.1	80.2	80.5	80.4	80.0	80.7	80.5	79.9
May 20-26	80.7	81.3	81.2	80.9	81.1	81.1	81.8	81.4	81.6	81.8	81.7	80.9
May 27-June 2 [4]	80.6	81.2	80.8	80.7	81.0	80.8	81.0	81.2	80.9	81.0	81.3	81.0
June 17-23 [5]	81.6	82.1	82.3	81.9	82.0	82.1	82.7	82.2	82.5	82.8	82.4	81.9
July 1-7 [6]	83.3	83.0	83.0	82.8	83.1	82.9	83.4	84.0	83.1	83.5	83.9	84.2
Aug. 12-18	84.7	84.4	84.2	84.2	84.5	84.2	84.7	85.2	84.6	84.7	85.1	85.5
Aug. 19-25	83.6	83.3	83.6	83.2	83.4	83.6	83.9	83.8	83.6	83.8	83.7	83.9
Aug. 26-Sept. 2	82.9	82.8	83.1	83.0	82.9	83.1	83.5	83.4	83.3	83.5	83.4	83.4
Sept. 3-9	82.8	82.8	83.2	83.2	82.7	83.2	83.5	83.4	83.4	83.4	83.4	83.4
Sept. 10-16	83.5	83.1	83.2	83.3	83.3	83.3	83.6	83.8	83.5	83.6	83.6	84.1
Sept. 17-23	83.2	82.8	82.8	83.0	82.9	82.9	83.7	83.7	83.7	83.6	83.5	84.0
Sept. 24-30	82.8	82.8	82.7	83.1	82.9	82.9	83.1	83.1	83.3	82.8	83.1	83.0
Oct. 1-7	81.4	81.3	82.7	83.0	81.4	82.8	82.7	81.5	82.7	82.7	81.7	81.3
Oct. 8-14	79.4	81.3	82.1	82.1	80.4	82.1	82.0	80.8	82.0	82.1	81.7	79.6
Oct. 15-21 [7]	78.8	81.0	81.3	81.3	80.1	81.3	81.4	80.1	81.4	81.4	81.0	78.7
Nov. 19-25	79.8	80.9	80.8	80.7	80.5	80.8	80.9	80.4	80.8	80.9	80.8	79.3
Nov. 26-Dec. 2	77.5	80.6	80.9	80.6	79.3	80.8	81.0	79.2	80.7	81.1	80.3	77.7
Dec. 3-9	75.4	79.4	79.7	79.7	77.9	79.6	79.7	77.7	79.8	79.6	78.7	75.6
Dec. 10-16	77.0	79.4	79.5	79.4	78.5	79.5	79.5	78.9	79.5	79.5	79.4	77.6
Dec. 17-23	75.2	75.0	78.8	78.8	75.2	78.9	78.9	75.3	78.8	78.9	75.3	75.2
Dec. 24-31	73.7	75.4	78.2	78.3	74.7	78.3	78.2	74.4	78.3	78.1	75.2	73.5
1930												
Jan. 1-7	75.5	78.1	78.1	77.9	77.4	78.0	78.1	77.3	77.9	78.1	78.0	75.6
Jan. 8-14	76.1	77.7	77.8	77.7	77.1	77.8	77.8	77.2	77.7	77.9	77.6	76.3
Jan. 15-21	74.6	78.0	78.6	78.0	76.8	78.4	78.8	76.3	78.4	79.0	77.7	74.4
Jan. 22-28 [8]	75.8	78.0	78.5	78.3	77.3	78.4	78.6	77.5	78.3	78.7	78.2	76.1
Jan. 29-Feb. 4	74.2	77.1	77.8	77.8	76.1	77.8	77.8	76.2	77.8	77.8	77.2	74.5
Mar. 11-17 [9]	74.0	73.9	77.6	77.6	73.9	77.6	77.7	73.8	77.6	77.8	74.1	74.4
Mar. 18-24	74.9	75.2	77.8	78.3	75.0	78.1	78.9	76.2	78.9	78.9	76.7	75.7
Mar. 25-31	73.5	75.6	78.2	78.3	74.8	78.1	78.1	75.3	78.1	78.1	76.1	74.2
Apr. 1-7	74.9	77.5	77.9	77.6	76.6	77.8	78.0	76.9	77.8	78.2	77.7	75.5
Apr. 8-14	74.1	74.7	77.8	77.7	74.3	77.8	77.9	75.8	77.8	78.0	76.5	74.7
Apr. 15-21	75.6	77.6	78.5	78.2	76.9	78.4	78.9	78.3	78.5	79.1	78.8	77.2
Apr. 22-28	78.0	78.4	79.6	79.1	78.3	79.4	79.8	78.7	79.3	80.1	78.9	78.3
Apr. 29-May 5	78.1	77.8	79.5	79.4	77.9	79.5	80.1	78.6	79.9	80.2	78.5	78.7
May 6-12	78.3	79.4	80.3	79.7	78.9	80.1	80.4	79.4	79.9	80.6	79.8	78.7
May 13-19	79.7	80.9	80.8	80.8	80.4	80.8	81.7	81.3	81.5	81.8	81.6	80.7
May 20-26	81.9	81.9	81.8	81.2	82.0	81.7	82.0	82.5	81.1	82.3	82.6	32.3
May 27-June 2	81.0	81.0	81.4	81.7	81.0	81.5	82.1	81.6	81.8	82.2	81.7	81.5
June 3-9	79.5	80.1	80.7	81.0	79.9	80.8	81.2	80.2	81.3	81.2	80.5	79.6

1 Aug. 12 to Sept. 2, 1928. No record; ship in port.
2 Oct. 1 to Nov. 11, 1928. No record; ship in port.
3 Jan. 15 to Feb. 18, 1929. No record; ship in port.
4 June 3 to June 16, 1929. No record; ship in port.
5 June 24 to June 30, 1929. No record; ship in port.
6 July 8 to Aug. 11, 1929. No record; ship in port.
7 Oct. 22 to Nov. 18, 1929. No record; ship in port.
8 Feb. 5 to Mar. 10, 1930. No record; ship in port.
9 Record for one day only in this week.

TABLE 3.—*The per cent the actual agreements of temperature trends are of the maximum possible agreements*

	Per cent of agreements: Up trends	Down trends	All trends
Maximum air temperature (day):			
Key West harbor	86	84	85
North half of Straits	79	84	82
South half of Straits	79	88	84
Minimum air temperature (night):			
Key West harbor	68	76	72
North half of Straits	61	72	67
South half of Straits	62	64	63
Mean air temperature (day):			
Key West harbor	86	84	85
North half of Straits	79	81	80
South half of Straits	74	81	78
Mean air temperature (night):			
Key West harbor	86	85	85
North half of Straits	72	77	75
South half of Straits	69	72	71
Key West harbor (day): North half of Straits	74	80	77
Key West harbor (night): North half of Straits	72	77	75
North half of Straits (day): South half of Straits	63	74	70
North half of Straits (night): South half of Straits	56	80	71
Habana harbor (day):			
Key West harbor	73	81	77
South half of Straits	58	71	65
Maximum air temperature	59	67	63
Maximum air temperature (night):			
Key West harbor	86	88	87
North half of Straits	72	80	77
South half of Straits	75	68	71

TABLE 4.—*Percentage of relationship, being the agreements of trend in excess of expectation by chance, expressed in per cent of the difference between chance and perfect agreement*

	Per cent in excess of chance agreements for— Up trends	Down trends	All trends
Maximum air temperature (day):			
Key West harbor	75	67	71
North half of Straits	61	63	62
South half of Straits	61	71	66
Minimum air temperature (night):			
Key West harbor	41	48	44
North half of Straits	29	29	29
South half of Straits	31	25	28
Mean air temperature (day):			
Key West harbor	74	65	69
North half of Straits	63	56	59
South half of Straits	53	54	54
Mean air temperature (night):			
Key West harbor	74	66	70
North half of Straits	50	42	46
South half of Straits	44	39	42
Key West harbor (day): North half of Straits	52	54	53
Key West harbor (night): North half of Straits	49	42	45
North half of Straits (day): South half of Straits	39	38	38
North half of Straits (night): South half of Straits	30	50	40
Habana harbor (day):			
Key West harbor	46	60	53
South half of Straits	16	32	22
Maximum air temperature	18	31	24
Maximum air temperature (night):			
Key West harbor	75	74	74
North half of Straits	49	50	49
South half of Straits	54	33	42

TABLE 5.—*The percentage of cases in which similar trends follow each other from week to week, the percentage of cases when such is not a fact, and the percentage of cases when the trend is steady from week to week*

	Per cent of continuity of trend	Per cent of discontinuity of trend	Per cent of steady trend
Maximum air temperature	50.0	45.2	4.8
Minimum air temperature	42.9	52.4	4.8
Mean air temperature	50.0	47.6	2.4
Key West harbor day temperature	38.1	57.1	4.8
Key West harbor night temperature	40.5	59.5	0.0
North half of Straits day temperature	52.4	40.5	7.1
North half of Straits night temperature	57.1	38.1	4.8
South half of Straits day temperature	47.6	47.6	4.8
South half of Straits night temperature	50.0	21.4	28.6
Habana Harbor day temperature	33.3	52.3	14.4

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REFLECTIVITY OF DIFFERENT KINDS OF SURFACES

By HERBERT H. KIMBALL and IRVING F. HAND

The reflection measurements and notes given in Table 2 were made by Mr. Hand while a passenger in an Army airplane, using the same photometer that was employed in obtaining the measurements given in the REVIEW, July, 1929, volume 57, pp. 291–295. The object of these flights was to measure the albedo, or the reflection coefficient for different kinds of surfaces under winter conditions.

On account of the cold, it was important that the photometer be read with minimum exposure of the observer to the wind. It was therefore necessary to reverse the position of the graduated spur wheel, *J*,[1] so that it could be read from above. In this new position the diameter of the projection of the iris opening from the white wedge, as read by the glass scale furnished with the instrument, increases with the reading of the photometer dial instead of decreasing as formerly. Compare in Table 1, calibration readings Nos. 3, 4, 5, and 6, made after the change, with Nos. 1 and 2, made before the change. In reading tenths of divisions on dial *K*,[1] it is now necessary to take the compliment of the reading instead of the direct reading.

TABLE 1.—*Iris diaphragm calibration—Photometer Munro No. 3*

Reading of photometer dial	Diameter of projection of iris from white wedge on glass scale in connection with outside of large window—iris closing					
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
	Centimeters	*Centimeters*	*Centimeters*	*Centimeters*	*Centimeters*	*Centimeters*
20	1.48	1.51				
21	1.36	1.36				
22	1.20	1.26				
23	1.10	1.12				
24	.96	1.01				
25	.84	.88				
26	.73	.73				
27		.59				
27.5		.53				
28.0		.46				
28.2		.41				
15			1.66		1.63	1.64
14			1.52		1.51	1.51
13			1.41		1.38	1.40
12			1.30		1.26	1.28
11			1.17		1.14	1.16
10			1.04	1.050	1.01	1.04
9			.91	.920	.88	.92
8			.79	.790	.75	.80
7			.64	.660	.63	.67
6			.51	.505	.51	
5.8				.485		
5.6				.465		
5.4				.420		
5.2				.405		
5.0				.380	.39	
4.8				.350		
4.6				.320		
4.4				.290		
4.2				.260		
4.0				.240		
3.8				.210		
3.6						

No. 1.—Mean of two readings each by Messrs. Kimball and Hand, Jan. 11, 1930.
No. 2.—Mean of one reading each by Messrs. Kimball and Hand, Jan. 11, 1930, paper separator in place holding neutral glass filter. This calibration for use with measurements over snow.
No. 3.—First calibration after dial was reversed. Mean of readings by Messrs. Kimball and Hand on Jan. 15, 1930.
No. 4.—Readings same date by same observers but with neutral glass and paper washer in place. For use with snow observations.
No. 5.—Check readings made Feb. 7, 1930.
No. 6.—Check readings made May 12, 1930.

[1] Richardson, L. F. Report on photometers for a survey of the reflectivity of the earth's surface. Union Géodésique et Géophysique Internationale, Section de Météorologie. Troisième Assemblée Générale. Prague, 1927. Cambridge, Eng., 1928.

Cloud conditions during the winter of 1929–30 were seldom favorable for reflectivity measurements. On days when there was a cloud cover of uniform thickness precipitation generally occurred before a flight could be made. Fortunately, February 1, following the only considerable snow storm of the winter (11.5 inches on January 30), was cloudy during the morning, and by flying north a snow cover that had been but little affected by the sunshine of January 31 was found. The results of the flight are given in Table 2, flight No. 1.

TABLE 2.—*Flight No. 1: Took off from Bolling Field at 10 a. m., February 1, 1930: returned at noon. Lieutenant Willis piloting OH-1 Douglass plane, "The Alabama." Ground covered with snow, which was 11.5 inches deep at Washington at 8 p. m. of January 30, 9.5 inches on January 31, and 5.5 inches on February 1. Neutral-glass filter transmitting 49 per cent ± 1 per cent covers sky window*

Ratio $\frac{A_s}{A_g}$	Reflection (unit=0.001)	Height above sea level (feet)	Filter	Position and notes
166	423	1,000	None	Over St. Elizabeths.
243	620	1,500	None	Park in Washington; very smoky and hazy.
196	500	1,500	None	Hyattsville, Md.
308	786	1,500	None	White field.
97	247	1,500	None	Forest.
291	742	1,500	None	White field.
338	862	1,500	None	Very white field.
349	890	1,500	None	Do.
283	722	1,500	Green	White field.
49	125	1,500	None	Dark forest.
36	92	1,500	None	Very dark forest.
291	742	2,000	None	White field.
248	633	2,000	Geeen	White field (near Sugar-Loaf Mountain).
299	763	2,500	None	Large white field.
54	138	2,500	None	Forest.
275	702	3,000	None	White field.
147	375	3,000	Red	White field; difficult setting.
38	97	3,000	None	Forest.
294	750	4,000	None	White field.
86	219	4,000	None	Forest; too cold at this height.
38	97	2,000	None	Baltimore; very smoky beneath.
38	97	2,000	None	Chesapeake Bay; smooth surface.
275	702	2,000	None	White field.

NOTE.—To obtain the reflection coefficient, or albedo, the ratio A_s/A_g has been multiplied by 1.25/.49=2.55, where the factor 1.25 makes allowance for the fact that the sky window admits light to the photometer from a sky area near the zenith, which is the brightest point in a completely overcast sky. The factor 0.49 is the transmission of the neutral glass screen.
The designation "White field" simply means a patch of snow large enough to give time in passing over it for an accurate setting of the photometer.

This was the first time that the plane had been taken out since it had been given a light overhauling. The flight was therefore serving a dual purpose—for observational work, and for a test flight. This latter necessitated at times speed in excess of 150 miles per hour with attendant vibrations, particularly of the photometer; but since this speed was maintained for brief periods only, it did not interfere with observations.

The photometer had been recalibrated with its dial changed from the lower to the upper side. Without this change it would have been impossible to read the instrument; in fact, with the heavy clothing needed for protection from the extreme cold, it would have been impossible to have even gotten into the plane with the